MISB MOTION IMAGERY STANDARDS BOARD	**MISB ST 0605.4**
STANDARD **Time Stamping and Metadata Transport in High Definition Uncompressed Motion Imagery**	**27 February 2014**

1   Scope

This Standard defines requirements for inserting frame-accurate time stamps and metadata in Key Length Value (KLV) format into the Serial Digital Interface (SDI) Vertical Ancillary Data Space (VANC) of SMPTE ST 292-1 (HD Image Formats) 720p, and SMPTE ST 424 (3G Image Formats) 1080p digital motion imagery.

2   References

2.1 Normative References

The following references and the references contained therein are normative.

[1]   SMPTE ST 291-1:2011 Ancillary Data Packet and Space Formatting
[2]   SMPTE ST 292-1:2012 1.5 Gb/s Signal/Data Serial Interface
[3]   SMPTE ST 424:2012 3 Gb/s Signal/Data Serial Interface
[4]   SMPTE RP 214:2002 Packing KLV Encoded Metadata and Data Essence into SMPTE 291M Ancillary Data Packets
[5]   MISB ST 0603.2 Time Stamping Digital Motion Imagery using Coordinated Universal Time (UTC), Feb 2014
[6]   SMPTE ST 352:2013 Payload Identification for Serial Digital Interfaces
[7]   SMPTE ST 12-2:2008 Television - Transmission of Time Code in the Ancillary Data Space
[8]   SMPTE ST 425-1:2011 Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface
[9]   SMPTE ST 296:2012 1280 x 720 Progressive Image 4:2:2 and 4:4:4 Sample Structure – Analog and Digital Representation and Analog Interface
[10] SMPTE ST 274:2008, Television - 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequence for Multiple Picture Rates
[11] MISB ST 0807.13 MISB KLV Metadata Dictionary, Feb 2014
[12] SMPTE RP 210v13:2012 Metadata Element Dictionary

3   Revision History

Revision	Date	Summary of Changes
0605.4	02/27/2014	- Removed requirement for Commercial Time Stamp - Revised to conform to EARS for requirements - Added Appendix Table 2

4   Introduction

Uncompressed High Definition (HD) formats have the capability to carry a large amount of data in the Vertical Ancillary Data Space (VANC). In capturing and mapping metadata to the VANC it becomes possible to align a motion imagery frame with metadata specific to that frame. Frame accurate time stamping of both motion imagery and metadata assures a deterministic relationship between the motion imagery and the metadata for further post processing/analysis.

5   Acronyms

ANC   Ancillary Data Space
DID   Data ID
HANC   Horizontal Ancillary Data Space
KLV   Key-Length-Value
MID   Message ID
PSC   Packet Sequence Count
SDI   Serial Digital Interface
SDID   Secondary Data ID
UDW   User Data Word
VANC   Vertical Ancillary Data Space

6   VANC KLV Encoding

Within the standards for uncompressed video, there are two reserved non-picture spaces – collectively termed the ancillary space or ANC – where data may be carried: the Horizontal Ancillary (HANC) and the Vertical Ancillary (VANC) data spaces. This Standard defines the encoding a Precision Time Stamp, a Commercial Time Stamp and KLV metadata into the Vertical Ancillary Data Space (VANC) of an uncompressed, high definition, motion imagery frame.

6.1 Encoding of KLV Metadata into the VANC

SMPTE ST 291[1] specifies the format of ancillary (ANC) data packets residing in the ancillary space defined by the physical interface document – SMPTE ST 292-1 [2] for HD-SDI 720p60 and 1080p30 and SMPTE ST 424[3] for 3G-SDI 1080p60. An ANC data packet contains a User Data Word (UDW) space for 255 10-bit words. Ancillary data may be present within the

horizontal ancillary data space (HANC) and the vertical ancillary data space (VANC); however, only VANC usage is allowed in this Standard.

Requirement	
ST 0605.4-01	The Precision Time Stamp, Commercial Time Stamp and KLV Metadata shall only be encoded into the Vertical Ancillary Data space (VANC).
ST 0605.4-02	KLV Metadata shall formatted in accordance with SMPTE RP 214[4].
ST 0605.4-03	The vertical ancillary data space (VANC) luminance data space within a frame shall be used for KLV data prior to using the chrominance data space.

For example, Line 9 Luminance data, Line 10 Luminance data, … Line 25 Luminance data, followed by Line 9 Chrominance data, Line 10 Chrominance data …etc.

SMPTE RP 214 [5] specifies a method for inserting KLV-formatted data into ANC packets. It also specifies: how to package 8-bit data within the 10-bit UDW space of an ANC packet; a Message ID (MID) field; and Packet Sequence Count (PSC).

6.1.1 VANC KLV Packet Formatting

Under the rules identified in Section 6.1, a VANC KLV Packet is formatted as shown Figure 1.
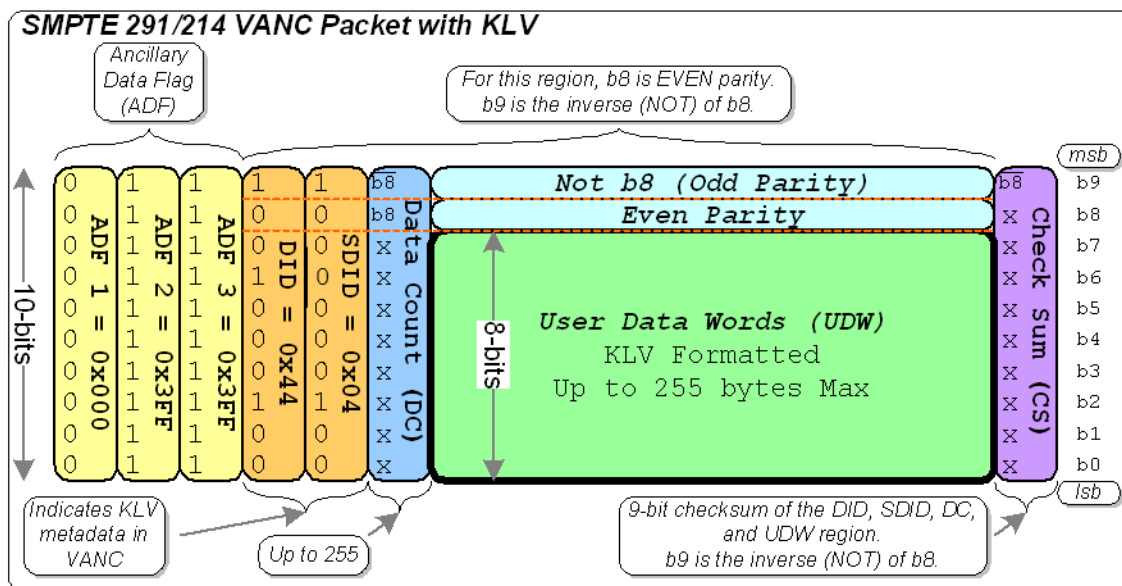

Figure 1: VANC Packet with KLV

Note that SMPTE RP 214 KLV metadata packets use a Data ID (DID) = 0x44, and Secondary Data ID (SDID) = 0x04. DID, SDID, Data Count (DC), and UDW space of the ANC packet for VANC KLV packets use bit 8 for even parity, and non-parity (logical NOT of bit 8) for bit 9. The maximum UDW space is 255 bytes with the size specified by the Data Count word.

6.1.2 User Data Words (UDW) Formatting for KLV data

For KLV applications, the User Data Words (UDW) section of an ANC data packet is formatted as shown in Figure 2.

The first three words within the UDW space are mandatory (SMPTE RP 214[4]). This leaves 255-3=252 bytes for a KLV payload within each VANC packet.

- ▪ The first word of the UDW space is a Message ID (MID) field, which identifies the ANC KLV packets belonging to the same KLV packet.

- ▪ The next two words of the UDW space represent a Packet Sequence Counter (PSC), which links long KLV packets to one another.

- ▪ The remainder of the UDW space is used to carry KLV metadata (up to 252 bytes). Over a digital interface, bit 8 of the KLV UDWs is the even parity of bits 0 through 7, and bit 9 is the logical NOT of bit 9.

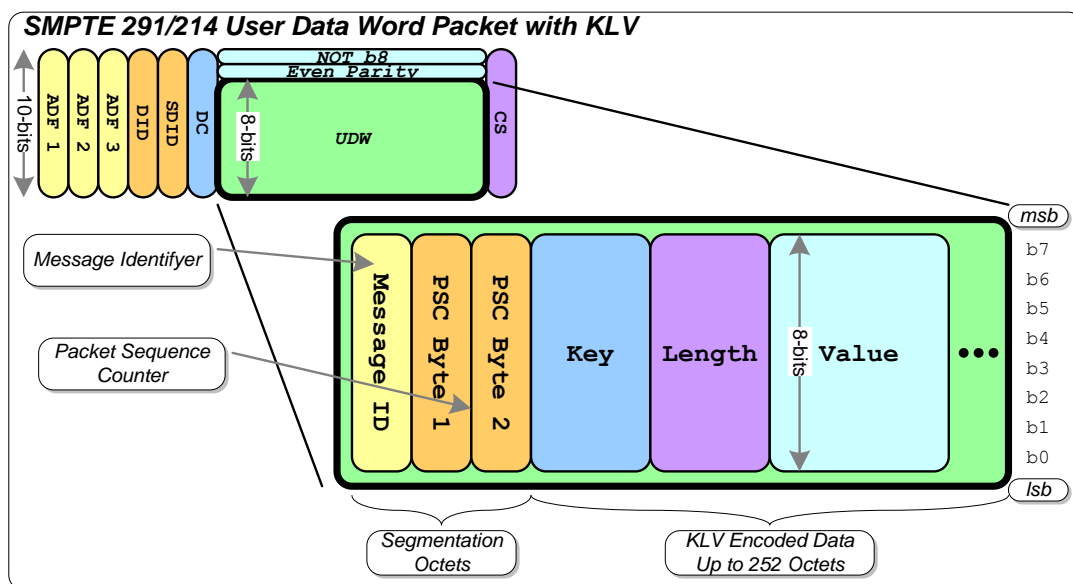Both the MID and PSC fields are discussed more in the sections that follow.

Figure 2: User Data Word Packet with KLV

6.1.2.1 Message ID (MID) Information

SMPTE RP 214 states that the MID value is used to identify packets that carry information belonging to the same message, and increments from 0x01 to 0xFF with each KLV packet sent within the VANC space.

Note: Previous versions of this document recommended using the MID field to convey additional information about the type of KLV data contained in the VANC packet. This older method allowed the same MID to be for multiple different KLV packets each falling into a common group (i.e. "Geospatial / Security Data" had a MID of 0x01).

When a second KLV packet is identified with the same MID value as a previous packet, the PSC is then repeated. Downstream systems then ignore the second set of VANC KLV packets as they have identical MID and PSC values as previous packets.

Requirement	
ST 0605.4-04	The practices for identifying Message ID (MID) values shall be in accordance with SMPTE RP 214 [4].

6.1.2.2 Packet Sequence Counter (PSC) Information

The PSC consumes the two user data words following the MID field. The two words form a two-byte value that represents the count of ancillary packets with the same MID value of the same KLV packet. The first data word of the PSC number represents the upper 8 bits and the second word of the PSC number represents the lower 8 bits of the 16-bit PSC number (bit 7 of the first word represents the MSB and bit 0 of the second word represents the LSB of the PSC value).

The first ANC packet for each different MID has a PSC value starting at 1, and increments by 1 for each successive VANC KLV packet required to carry the KLV packet.

7 VANC Precision Time Stamp Pack

A **VANC Precision Time Stamp Pack** is composed of three items: a Pack Key, the Length of the Value (in bytes), and a Value. The Value is composed of two subfields (see Figure 3):

1) A one-byte Time Stamp Status value that provides state of the source time reference (as defined in MISB ST 0603[5]). The key is defined in MISB ST 0807[11] as 06.0E.2B.34.01.01.01.01.0E.01.01.03.10.00.00.00 (CRC 30903).

2) A 64-bit (8-byte) Precision Time Stamp (as defined in MISB ST 0603 [5]). The key is defined in SMPTE RP 210 [12] as 06.0E.2B.34.01.01.01.03.07.02.01.01.01.05.00.00 (CRC 64827).
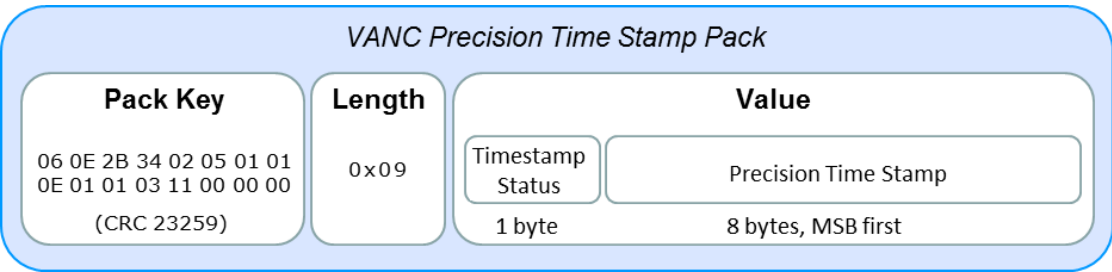

Figure 3: VANC Precision Time Stamp Pack

7.1 Time Stamp Status

The Precision Time Stamp, when inserted into motion imagery is accompanied by a one-byte Time Stamp Status value that provides information about the timing source reference.

7.2 Precision Time Stamp

The Precision Time Stamp is an 8-byte value as specified in MISB ST 0603 [5]. The 8-byte Precision Time Stamp is mapped into the VANC space of a motion imagery frame following the Time Stamp Status value. Table 1 shows the byte ordering, where byte 1 is the most significant byte of the Precision Time Stamp.

Table 1: Byte Assignment for 64-bit Precision Time Stamp

Bytes 1,2	Byte 1 and 2 (Most significant bytes) of Precision Time Stamp
Bytes 3,4	Byte 3 and 4 of Time Stamp
Bytes 5,6	Byte 5 and 6 of Time Stamp
Bytes 7,8	Byte 7 and 8 (Least significant bytes) of Precision Time Stamp

7.3 Encoding Precision Time Stamp into the VANC

Requirement	
ST 0605.4-05	A VANC Precision Time Stamp representing Coordinated Universal Time (UTC) of the start of the active motion imagery frame shall be present in a SMPTE RP214 packet in the VANC space of each uncompressed motion imagery frame.
ST 0605.4-06	The VANC Precision Time Stamp Pack shall contain the Key (in hex) 06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259).
ST 0605.4-07	The VANC Precision Time Stamp Pack shall contain the Length (in hex): 0x09.
ST 0605.4-08	The VANC Precision Time Stamp Pack shall contain the Time Stamp Status.
ST 0605.4-09	The VANC Precision Time Stamp Pack shall contain the Precision Time Stamp.
ST 0605.4-10	The VANC Precision Time Stamp Pack shall be the first SMPTE ST 291 packet on Line 9 of the video frame.

Additional SMPTE ST 291 packets may follow the VANC Precision Time Stamp Pack on line 9.

8   Encoding Commercial Time Stamp into the VANC

To improve interoperability with commercial video equipment, a Commercial Time Stamp as defined in MISB ST 0603 may be inserted into each motion imagery frame. This time stamp is formatted into a SMPTE ST 291 packet according to SMPTE ST 12-2[7].

Requirement	
ST 0605.4-11	When available, a Commercial Time Stamp representing the relative Coordinated Universal Time (UTC) of the start of the active motion imagery frame shall be present in a SMPTE ST 12-2[7] packet in the VANC space of each uncompressed motion imagery frame.
ST 0605.4-12	When present, the Commercial Time Stamp shall be the first SMPTE ST 291 packet on Line 14 of the motion imagery frame.

9 Motion Imagery Payload Identification

SMPTE ST 424 [3] relies on SMPTE ST 425 [8] for identifying the source image format conveyed over the physical interface. SMPTE ST 425 mandates that a Payload Identifier (specified by SMPTE ST 352 [6]) be included in the horizontal space of the digital stream.

10 Additional Requirements

Requirement	
ST 0605.4-13	No KLV data is allowed on line 14. Additional KLV packets shall continue on Line 15. Other non-KLV data packets are allowed on line 14 after the Commercial Time Stamp.
ST 0605.4-14	The insertion of KLV data in a frame shall discontinue once the end of the VANC is reached.
ST 0605.4-15	When inserting VANC data packets containing non-KLV data, those packets shall follow all VANC packets containing KLV data.

Annex A - Uncompressed HD Motion Imagery – *Informative*

Uncompressed HD motion imagery consists of uncompressed HD video and KLV metadata with a time stamp embedded in the VANC. The MISB has approved the HD progressive mode standards outlined in SMPTE ST 296 [9] and SMPTE ST 274 [10]. This Annex describes the data carrying capabilities of the VANC data space for 720p and 1080p high definition systems.

11 HD VANC Overview

11.1 *SMPTE ST 296 (720p)*

SMPTE ST 296 1280x720 format (Figure 4) consists of 750 data lines, where 720 lines represent the active image area of an uncompressed video frame. The 30 remaining lines represent the Vertical Ancillary Data Space (VANC) of which 20 lines can be used to store data. Lines 1-5 and 746-750 are reserved for buffer/sync space between the usable data lines.
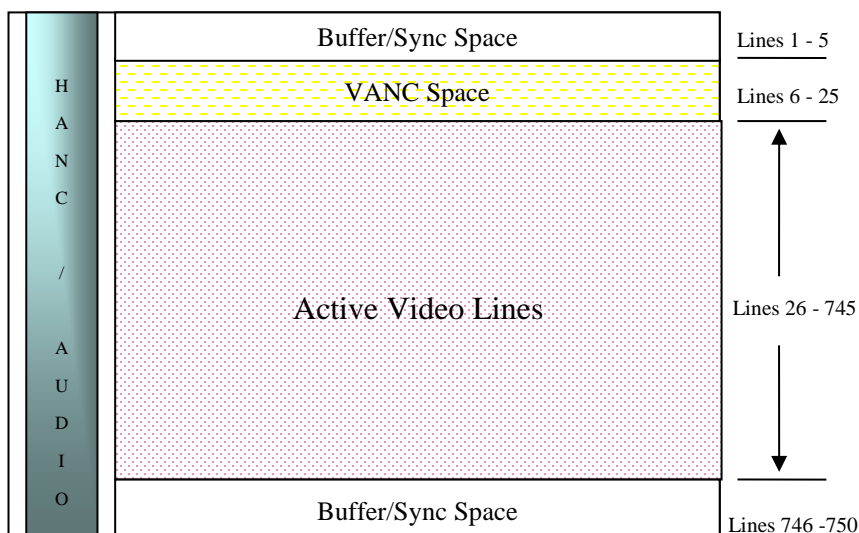

Figure 4: SMPTE ST 296 720p Video Frame

11.2 *SMPTE ST 274 (1080p)*

SMPTE ST 274 1920x1080 HD format (Figure 5) consists of 1125 data lines, where 1080 lines represent the active image area of an uncompressed video frame. The 45 remaining lines represent the Vertical Ancillary Data Space (VANC) of which 36 lines can be used to store data. Lines 1-5 and 1122-1125 are reserved for buffer space between the usable data lines.
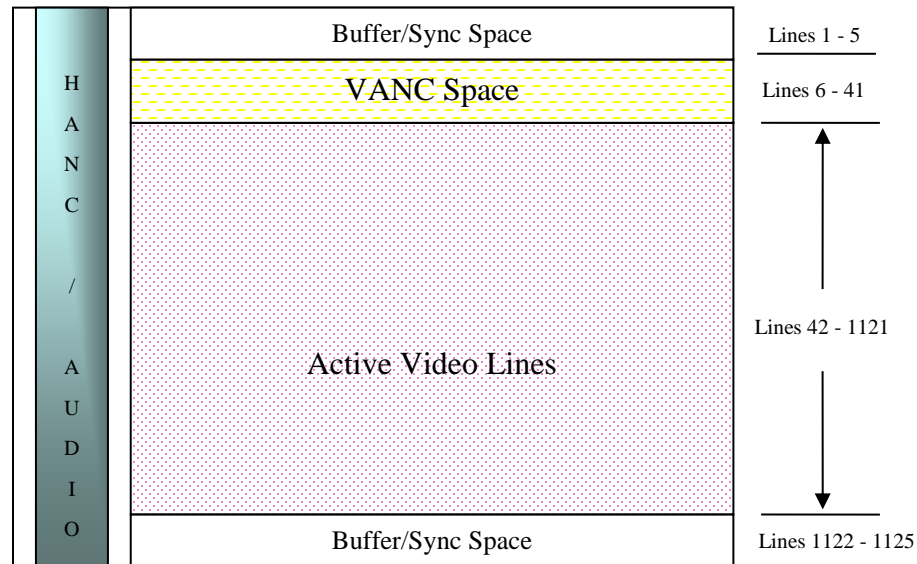
Figure 5: SMPTE ST 274 1080p Video Frame

12 VANC Capacity for KLV metadata

SMPTE ST 291[1] outlines the procedures for creating and inserting VANC data packets into the VANC space. Each data packet has 10-bytes of overhead (3-bytes for ADF, 1-byte DID, 1-byte SDID, 1-byte DC, 1-byte MID, 2-byte PSC, 1-byte CS), and a maximum of 252 bytes available for KLV data. The following sections elaborate on the metadata capacity available for both 720p, and 1080p systems.

12.1 SMPTE ST 296 (720p) Metadata Capacity

A 720p motion imagery frame has a capacity of 1280 words (bytes) per line, and can accommodate a minimum of five completely filled VANC packets. Since each packet contains 10 bytes of overhead each line can support a maximum of 1280 – (5 packets x 10 bytes/packet) = 1230 bytes. VANC packets can exist on lines 9-13, and 15-25 comprising the 16 lines of available luminance space. VANC packets can also exist in the chrominance space of the motion imagery for a total of 32 lines for metadata. Thus, 1230 KLV bytes/line x 32 lines = 39,360 bytes per 720p frame. At 60 Hz, this equates to a data rate of 18.89 Mbps.

12.2 SMPTE ST 274 (1080p) Metadata Capacity

A 1080p motion imagery frame has a capacity of 1920 words (bytes) per line, and can accommodate a minimum of 8 completely filled VANC packets. Since each packet contains 10 bytes of overhead, each line can support a maximum of 1920 – (8 packets x 10 bytes/packet) = 1840 bytes. VANC packets can exist on lines 9-13, and 15-41 comprising the 32 lines of available luminance space. VANC packets can also exist in the chrominance space of the motion imagery for a total of 64 lines for metadata. Thus, 1840 KLV bytes/line x 64 lines = 117,760 bytes per 1080p frame. At 60 Hz, this equates to a data rate of 56.52 Mbps.

13 HD-SDI and 3G-SDI Standards

Table 2 lists the image formats supported by SMPTE standards referenced in this document.

Table 2: HD-SDI and 3G-SDI Formats & Standards

Nomenclature	Image Format Standard	SDI Interface Standard	Active Pixels	Active Lines	Field Rate	Frame Rate	SDI Bit Rate (Mb/s)
HD-SDI							
720p60	SMPTE ST 296	ST 292-1	1280	720		60	1485
720p59.94	SMPTE ST 296	ST 292-1	1280	720		59.94	1483
720p50	SMPTE ST 296	ST 292-1	1280	720		50	1485
720p30	SMPTE ST 296	ST 292-1	1280	720		30	1485
720p29.97	SMPTE ST 296	ST 292-1	1280	720		29.97	1483
720p25	SMPTE ST 296	ST 292-1	1280	720		25	1485
1080i60	SMPTE ST 274	ST 292-1	1920	1080	60	30	1485
1080i59.94	SMPTE ST 274	ST 292-1	1920	1080	59.94	29.97	1483
1080i50	SMPTE ST 274	ST 292-1	1920	1080	50	25	1485
1080p30	SMPTE ST 274	ST 292-1	1920	1080		30	1485
1080p29.97	SMPTE ST 274	ST 292-1	1920	1080		29.97	1483
1080p25	SMPTE ST 274	ST 292-1	1920	1080		25	1485
3G-SDI							
1080p60	SMPTE ST 425-1	ST 424	1920	1080		60	2970
1080p59.94	SMPTE ST 425-1	ST 424	1920	1080		59.94	2967.03
1080p50	SMPTE ST 425-1	ST 424	1920	1080		50	2970